(14) AFAMRL-TR-80-25

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AD A088100

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VOICE COMMUNICATION RESEARCH AND EVALUATION SYSTEM.

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(9) Technical rept.,

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NOTICES

TECHNICAL REVIEW AND APPROVAL

AFAMRL-TR-80-25

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

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AIR FORCE/56780/27 June 1980 — 150

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: AFAMRL-TR-80-25	2. GOVT ACCESSION NO.: AD-A088 100
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): VOICE COMMUNICATION RESEARCH AND EVALUATION SYSTEM	5. TYPE OF REPORT & PERIOD COVERED: Technical Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Richard L. McKinley	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Air Force Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, OH 45433	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 62202F/7231/09/11
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: May 1980
	13. NUMBER OF PAGES: 17
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Communications; Speech; Electronic Warfare; Noise; Voice Communication; Speech Intelligibility; Psychoacoustics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Aircraft voice communications may be degraded by a variety of sources such as electrical and/or acoustical noise, radio interference, jamming and various other forms of distraction. The Voice Communication Research and Evaluation System, located in the Biodynamics and Bioengineering Division of the Aerospace Medical Research Laboratory, has been developed for the comprehensive analysis and enhancement of operational voice communication. The basic system is comprised of a multi-station voice communication network consisting of the USAF

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standard aircraft intercommunication system, a standard A-19 diluter-demand oxygen regulation system and an on line computer data collection and data analysis system that displays results in real time. The system is housed in a large reverberation chamber containing a programmable sound source capable of reproducing the spectrum and level of any AF operational noise environment. Standardized voice communication effectiveness test materials are used to assess the performance of any aspect of the total voice communication link, however, emphasis is usually placed upon the performance of the aircrew members. This paper will describe the salient features of this unique system and provide examples of its application to voice communication problems.

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INTRODUCTION

Air and ground crew voice communications may be degraded by a variety of system and environmental factors that include electrical or acoustical noise or both, radio interference, jamming, communication signal processing and various other factors that prohibit effective communication. Vigorous research activities must be maintained to identify and quantify elements that cause such deterioration and to develop principles, techniques and guidelines that will minimize adverse effects and optimize voice communications. Analytical studies of communication system performance, environmental influences and the man-in-the-loop element must be carried out under carefully controlled conditions that simulate to the greatest extent possible, the practical, operational situations of concern. Such efforts are possible in controlled laboratory environments where special instrumentation can be used to create the essential elements of human factors and communication system networks being investigated.

A Voice Communication Research and Evaluation System (VOCRES), located in the Biodynamics and Bioengineering Division of the Air Force Aerospace Medical Research Laboratory has been developed to provide the capability for comprehensive research, test and evaluation activities in the voice communications effectiveness arena. VOCRES, the subject of this report, has been designed to replicate system and environmental variables believed to have significant influence on operational communication. Using VOCRES, various elements of voice communications can be analyzed either individually or in component clusters. Using this method of analysis, problem areas can be identified, attacked and the overall operation enhanced. The effectiveness of various interfering signals may also be evaluated by their insertion into the communication system. The operational procedures and materials used in the laboratory are well standardized and provide data with a high degree of reliability.

This report describes the VOCRES system instrumentation in some detail as well as the psychoacoustical procedures used in the overall operation of the voice communication research program. The key element of the overall program is VOCRES. Other component systems are essential to the realistic replication of communication situations for expanding the technology base as well as performing discrete measurements required for the treatment of specific problems.

APPROACH

The general approach employed in this program involves the participation of volunteers who communicate as talkers and listeners under controlled conditions that replicate the specific communication environments being evaluated. Subjects are stationed at custom-designed consoles and communicate with standardized or special purpose (speech) vocabulary materials while various system and environmental characteristics or equipment are varied and the resulting communication effectiveness is quantified. Elements commonly varied are microphones, earphones, ambient noise level at the crew station, helmets and oxygen masks, aircraft radios, jamming signal type and modulation, jammer to signal power ratios, and receiver input power. Data derived from these efforts may be used to establish baseline communication system performance profiles, for comparative testing of specific communication system components, such as radios, intercoms, microphones, earphones, and voice processors. The data are also used to

quantify the performance of a specific component in a specific environment. Subjective comments from active aircrew personnel who have experienced the VOCRES reveal that the validity of the system and of the approach is quite good.

INSTRUMENTATION

VOCRES: General System

The VOCRES system is an aggregate of four different subsystems integrated into a voice communication network that includes ten individual communication stations and one control station. The individual communication consoles are located in a large reverberation chamber and the master console is located in a control room adjacent to the chamber. The general physical assemblage of the individual subsystems and the integrated system is displayed in Figure 1.

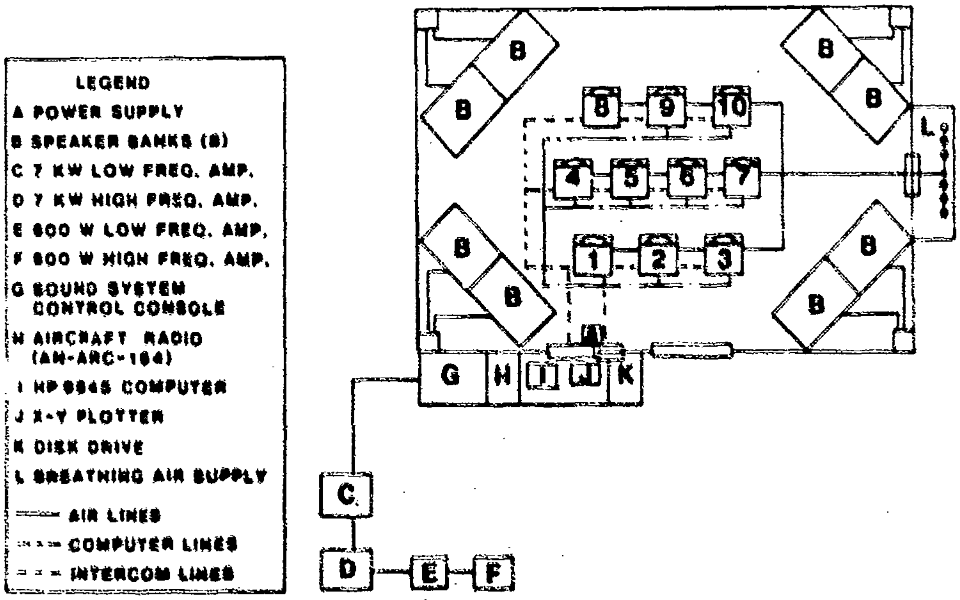

Figure 1. SUBSYSTEMS INTEGRATION

The subsystems include (1) an AIC-25 aircraft intercommunication system (11 stations), for use with Air Force standard communications headgear, (2) an air respiration system with A-19 diluter-demand regulators for use with standard oxygen masks, (3) a high intensity sound source for duplicating operational acoustical environments occupied by crew members and (4) a central processing unit that controls all stations and conducts the individual testing sessions and conditions, i.e., presents materials, monitors participant activity, records, stores and analyzes responses, and provides analyzed data in tabular or graphic form or both. The overall system is adaptable to the incorporation of various aircraft radios, communication jammers, and the like, that are not integral components of VOCRES.

Each of the ten communication consoles or stations is equipped with an AIC-25 intercommunication terminal, an A-19 respiration terminal, a display/subject response unit, a keyboard for communication performance task response from the participants and

a large volume unit (VU) meter that indicates voice level of communications generated at that station (see Figure 2). The system can be operated with any number of one to ten volunteers. The psychophysical paradigm used most often is a "round robin" procedure where each subject, in turn, performs as a talker while the remaining subjects respond as listeners.

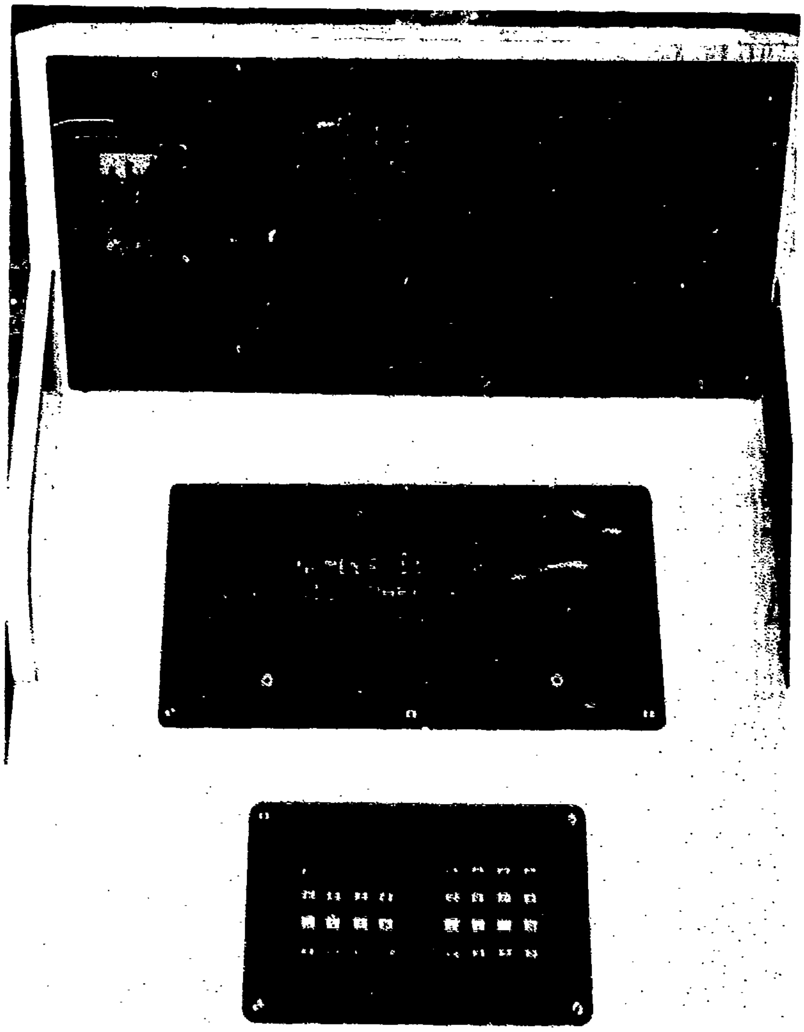

Figure 2. INDIVIDUAL VOCRES STATION (DESK)

COMMUNICATION MATERIALS

Communication materials consist of the standardized Modified Rhyme Test* for most activities with VOCRES. Other test materials such as the Diagnostic Rhyme Test are used from time to time for special purpose applications.

COMMUNICATION LINK CAPABILITIES

The communications assemblage diagram (Fig. 3) demonstrates the high flexibility of VOCRES that allows a variety of different communication links to be examined either

* Standardized lists of 50 monosyllabic words; each list developed to be essentially equivalent in intelligibility to the other lists.

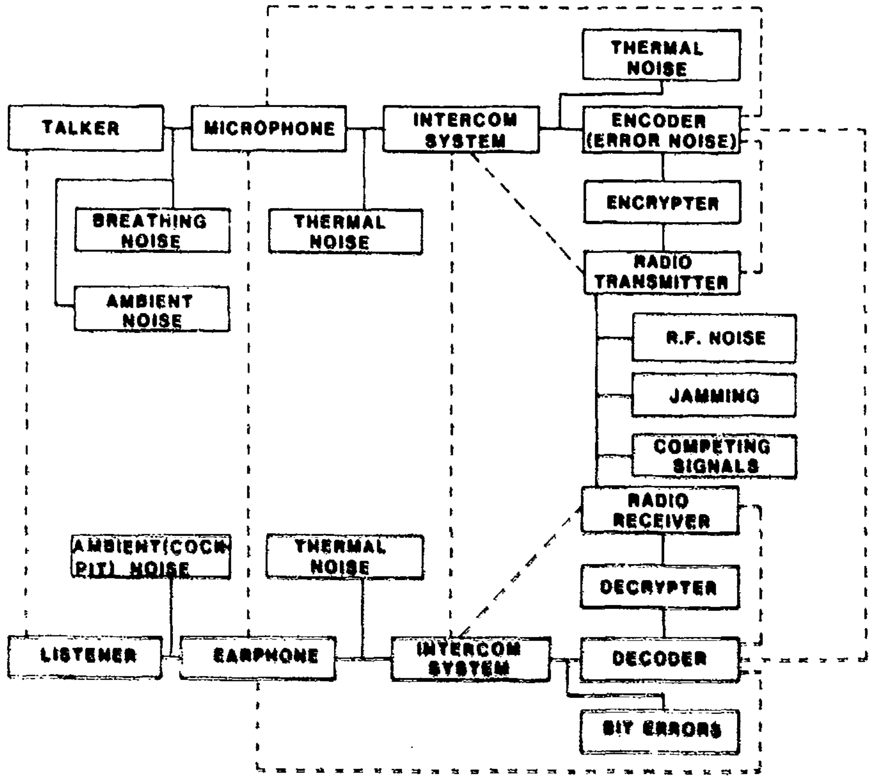

Figure 3. BLOCK DIAGRAM VOCRES COMMUNICATION LINK

individually or in combination with one another. The range of communication links can be varied from a simple face-to-face communications situation (i.e., direct talker to listener) to a complex configuration using encoders, encrypters, and the like by varying appropriate subunit controls. Any of the alternate pathways shown in Figure 3 can be used to complete the talker to listener link. The direct talker to listener path theoretically provides a data baseline free from environmental and component effects. The influences of the various elements of the communication system operation relative to the baseline can be quantified, analyzed and evaluated by measuring performance while varying single components and clusters of components of the VOCRES.

CENTRAL PROCESSOR-DISPLAY-RESPONSE SYSTEM

The control console of the system includes a typewriter type keyboard and a cathode ray tube (CRT) display. Through this console the test administrator enters the required experimental information. The central processing unit then displays the required instrument on the CRT (Fig. 4). After all experimental instrument settings are completed and stabilized, the administrator tells the central processing unit to administer the selected test and collect data from each of ten individual communications desks. The system is capable of making any one of the 10 stations the talker position and also can facilitate multiple talkers. For example, during a test one subject will be designated a talker for a list of 50 words and the other nine subjects will be designated as listeners. On the CRT the system displays each of the listeners' responses to each item spoken by the talker. The CRT display also indicates whether or not the response is correct (Fig. 5). The central processor-display-response system is diagrammed in Figure 6. The central processor is the Hewlett-Packard 9845T System. This system has dual 16-bit processors,

wherein one handles internal functions, while the second handles I/O functions. Also included in the basic system are a CRT with graphics, a thermal line printer (8-1/2" wide) with graphics capability and two cartridge tape drives, each with 217K byte* capacity. A 20 Mega byte disk drive with two platters, one fixed and one removable, adds additional data storage capability. Several interfaces are also included in the system. An RS-232 interface is used for sending and receiving data from the individual communication stations, while an IEEE 488-1975 General Purpose Interface Bus is used for control and data collection from various electronic instruments. These include a digital spectrum analyzer, a frequency synthesizer, a digital voltmeter, an RF power meter, and a 4-color flat bed X-Y plotter. A second RS-232 interface receives data from a digital oscilloscope or an audio tape deck.

Each individual communication desk has its own RS-232 compatible interface shown in Figure 4 & 5 which decodes commands by the central processor for the display system and also returns the subjects' responses to the central processor for storage and analysis. Each desk station interface has two addresses to which it will respond. One address is common to all desks, therefore by using one address and message, all desk displays can be activated or loaded simultaneously. The second address is specific to only one desk and by using this address, ten different messages can be loaded into each of ten different displays. The interface for each desk operates at 9600 bits per second allowing seemingly simultaneous operation at each of the ten stations.

Figure 7 shows one of the 64 character alphanumeric gas discharge, type displays. Each character is 5.73 mm (.023 in) x 8.27 mm (0.33 in) and is generated by a 5x7 dot matrix with a separate underline capability. The display is very bright having a level of 30 ft-L. The contrast of the neon-orange characters is enhanced by the use of a circularly polarized filter.

The subjects can respond by using one of two different response systems. The first system consists of six pushbuttons, three on either side of the displays each with a red LED mounted in the bezel. Pressing one button causes the adjacent LED to light indicating a response has been made. Pushing a second button will allow the volunteer to change his decision, illuminating the second light instead of the first. The second response system consists of two 4x4 calculator type keypads. Only one of the 32 buttons can be chosen at one time. Operation is similar to the six LED pushbuttons except that pressing one of the keys causes from one to five of the six LEDs to light forming a specific pattern for that key. These LEDs provide feedback to the subject indicating the chosen response.

DATA TREATMENT

Computer software was developed to standardize test procedures and to facilitate the administration of the Modified Rhyme Test or any other standardized intelligibility test over a large number of individual trials. The software also includes the experimental design. Each test parameter is displayed on the CRT before the trial and appropriate equipment settings are made by both the test administrator and central processing unit. The individual units of the Modified Rhyme Test or any other test materials are stored on the system's 20 Mega Byte hard disk. Following each trial, data for each subject, all test parameters and the time of the trial are stored on the system's disk. Fail-safe backup is accomplished by printing the same data on the system's thermal line printer. The data

* Note: 1 byte = 8 bits

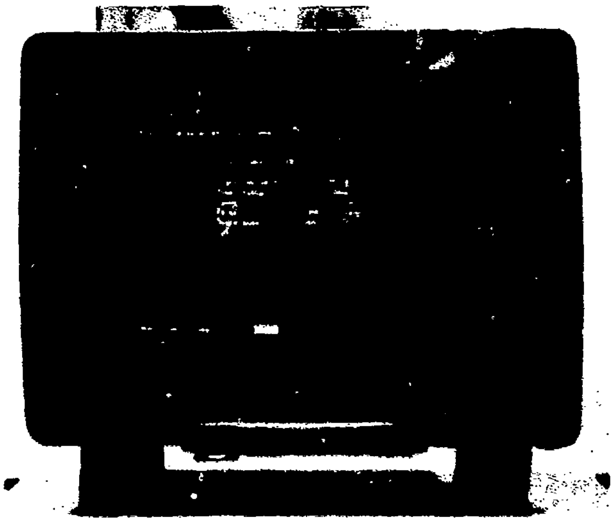

Figure 4. CENTRAL PROCESSING UNIT, CRT. OPERATOR PROMPTING

Figure 5. CENTRAL PROCESSING UNIT, CRT. SUBJECT RESPONSES

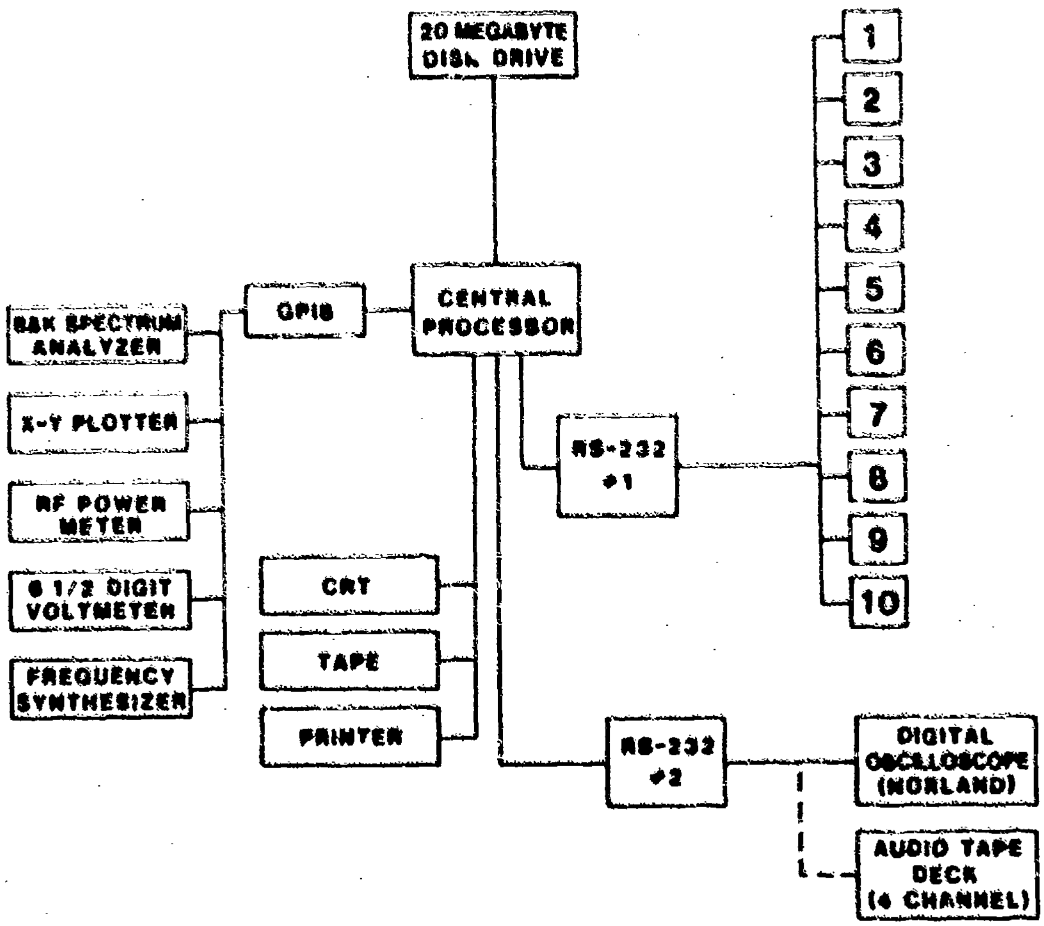

Figure 6. BLOCK DIAGRAM VOCRES CENTRAL PROCESSING UNIT

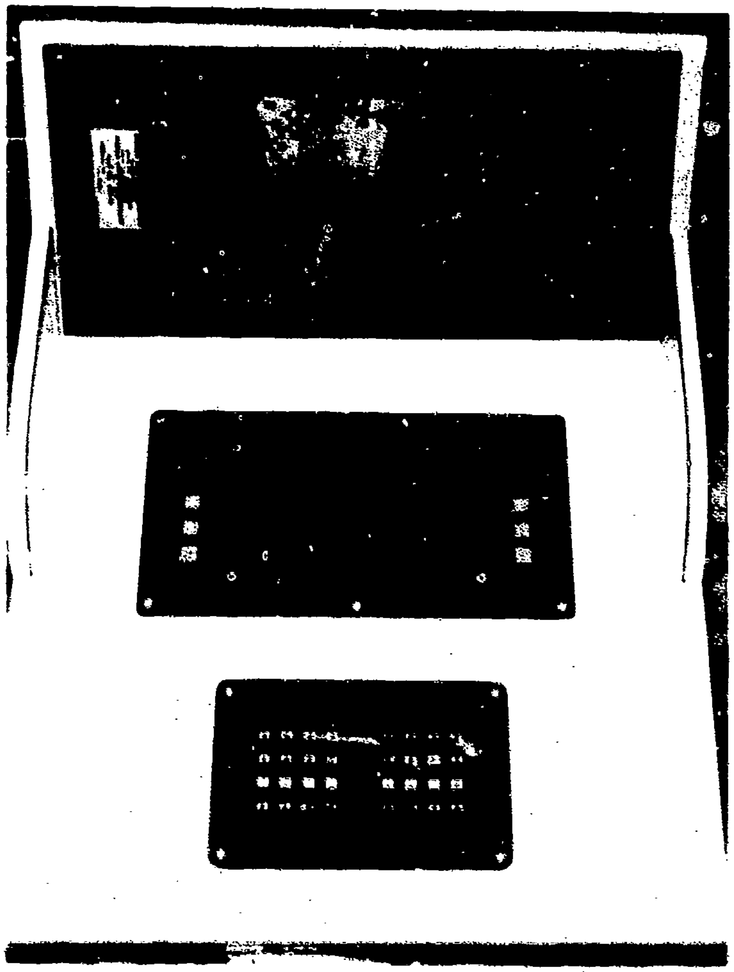

Figure 7. INDIVIDUAL DESK DISPLAY UNIT

may be analysed at any time, using a variety of standard statistical measures and plotting techniques. This method of data storage and analysis can give preliminary results in real time.

HIGH INTENSITY SOUND SYSTEM

The high intensity sound system is shown in Figures 8 and 9. The system is capable of operation in one of two power modes, a high power mode where 14,000 watts are available and a low power mode where 1,200 watts are available. The power amplifiers drive eight banks of loudspeakers containing a total of 96 Altec 15" low-frequency speakers, eight Altec horn loaded compression drivers, and 384 Stromberg Carlson high frequency speakers. The noise generator and the spectrum shaper allow almost any desired noise environment (spectrum) within the human audio-frequency range to be generated inside the test chamber. This permits the accurate reproduction of ambient and environmental noise conditions of specific operational situations within the laboratory, which is a vital aspect of the validity of the communication testing.

The room in which the loudspeaker banks are located is a specially designed and constructed acoustic reverberation chamber. The room is designed for maximum

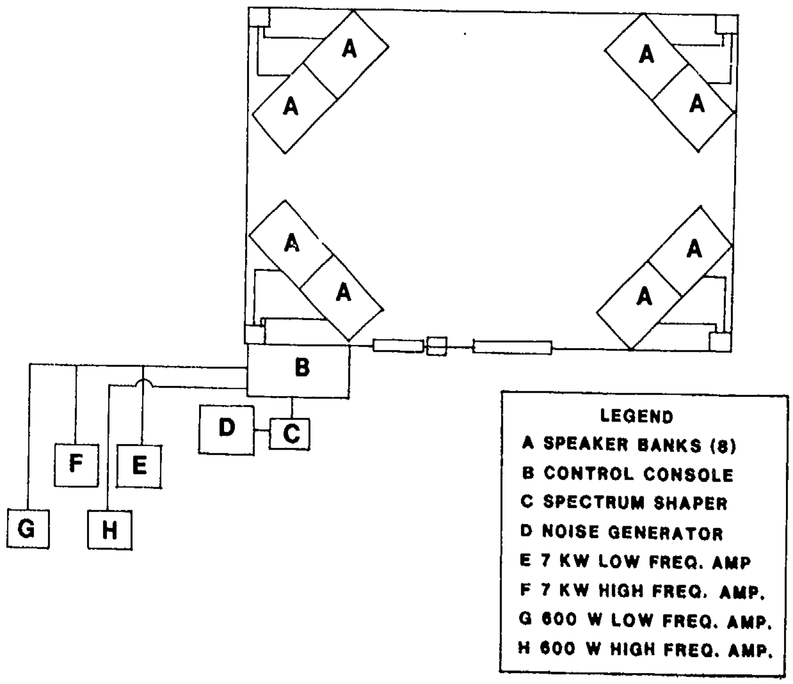

Figure 8. HIGH INTENSITY SOUND SYSTEM

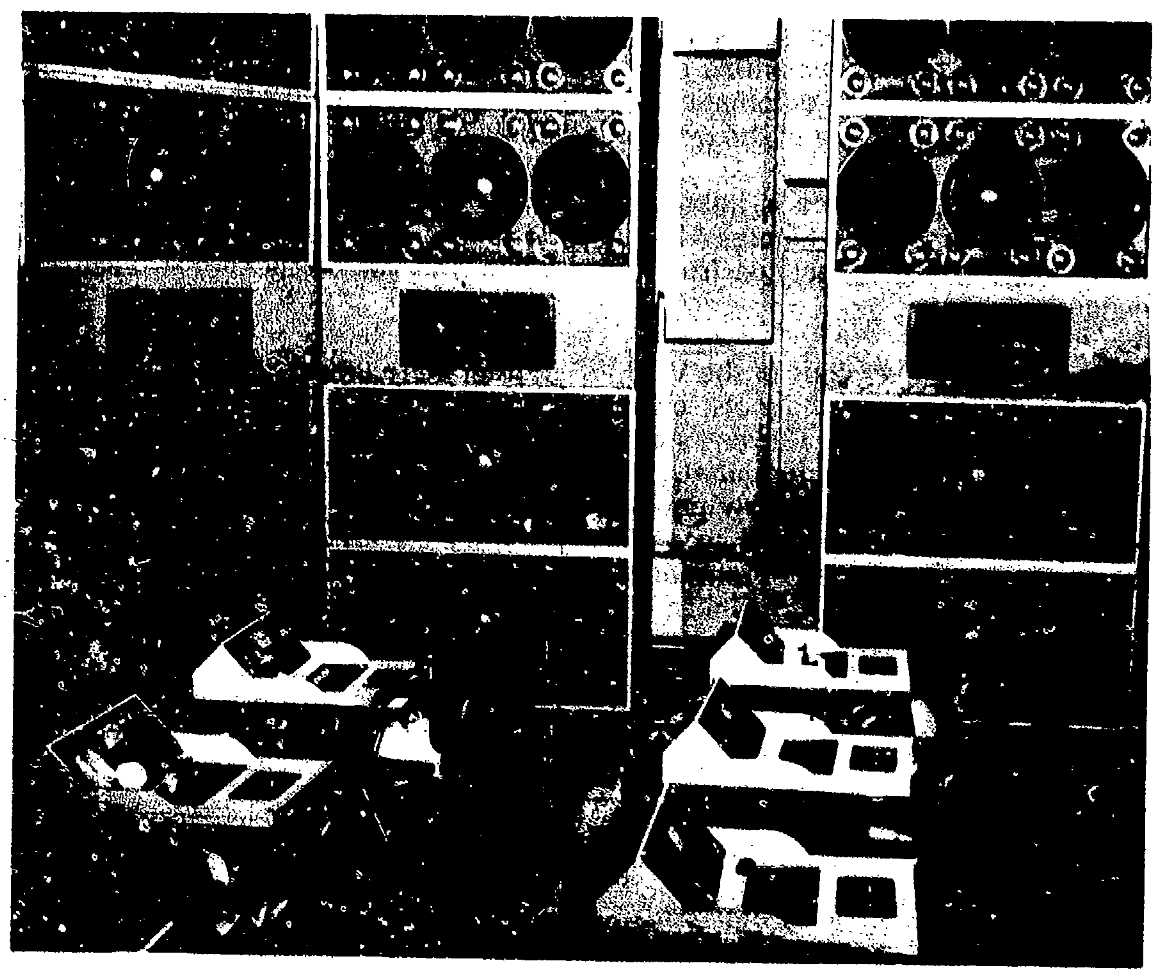

Figure 9. HIGH INTENSITY SOUND SYSTEM

reverberation time and approximately 8000 ft^3 in volume. The irregular wall surfaces are designed to disrupt the formation of standing waves and maximize the uniformity of the level of a noise distributed throughout the room.

AIC-25 INTERCOMMUNICATION SYSTEM

The aircraft intercommunication system shown in Figure 10 is a standard AIC-25 intercommunication system. The test administrator and each desk has an individual AIC-25 aircraft intercommunication unit . A switching circuit located on the control console allows the talker's intercom to be disconnected from the rest of the system and taken directly to the audio input of any transmitter. The audio output of the receiver is then routed to the other nine listeners. The terminal equipment available for the intercom system includes standard H-157A headsets, H-133 headsets, MBU-5/P oxygen masks, and HGU-26/P flight helmets. A sample of each of these is pictured in Figure 11.

AIR RESPIRATION SYSTEM

The air breathing system depicted in Figure 12 uses the standard Air Force A-19 diluter demand regulator as the primary item in the system. Each station has its own A-19 regulator which is supplied through feeder lines by a semiautomatic regulator manifold. The manifold connects six standard size breathing air bottles to the system through two regulators. Each regulator controls three bottles. When the supply of the first three bottles is exhausted the system automatically switches to the second set of three bottles. The normal operating pressure in the system is 150 psig.

Each of the above systems is integrated into each of ten individual subject stations. The final product is shown in Figures 13 and 14. The desk was designed for minimum size to minimize acoustical reflections from the surface and yet be functional. Each station is independent.

In the past, interim versions of the VOCRES system were used to evaluate communication properties of lightweight helmets, chemical defense ensembles, new oxygen masks, and innovative radio systems. Current studies involve the investigation of effects of jamming on communication in a quantitative manner relative to the J/S, S/N, radio type and jammer type, evaluation of new chemical defense ensembles, and development of new communication microphones. Future studies will include modeling of human response to jamming and enhancement of terminal communication equipment.

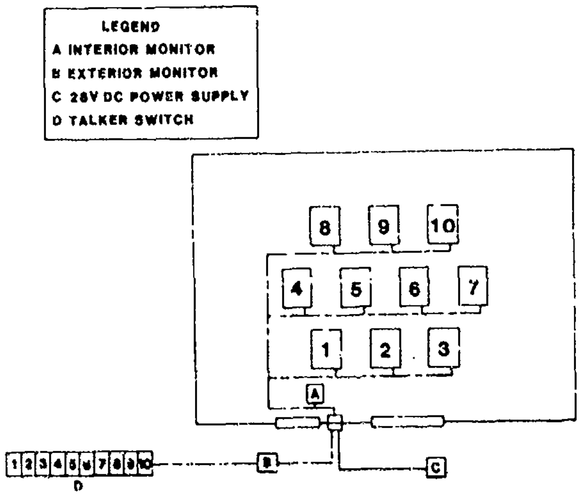

Figure 10. AIC-25 INTERCOMMUNICATION SYSTEM

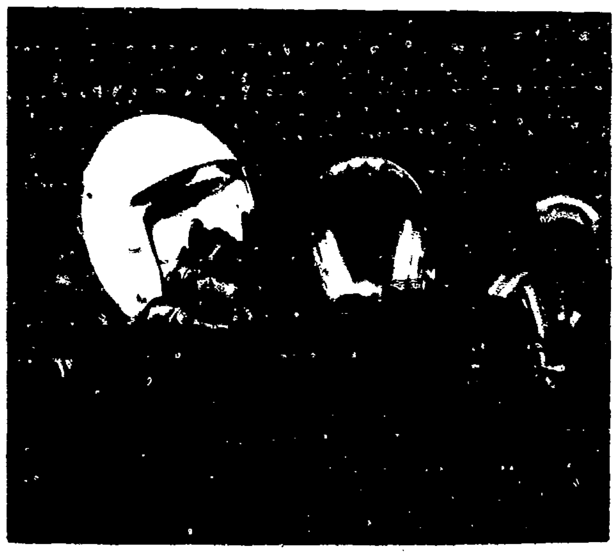

Figure 11. AIC-25 COMPATIBLE TERMINAL HEADGEAR

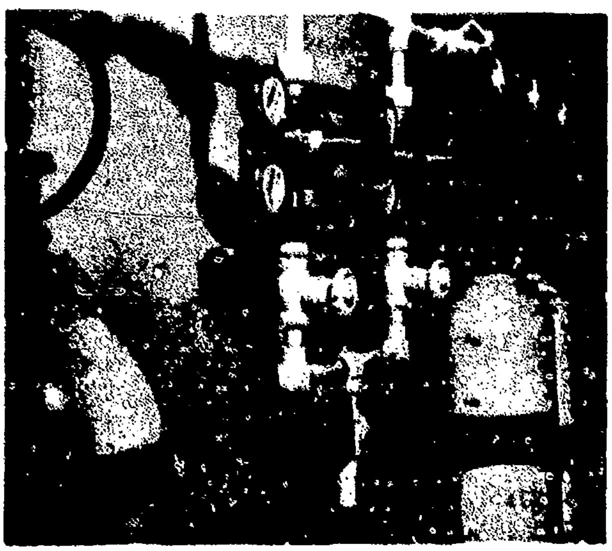

Figure 12. AIR RESPIRATION SYSTEM

Figure 13. INDIVID' AL VOCRES STA'ION (DESK)

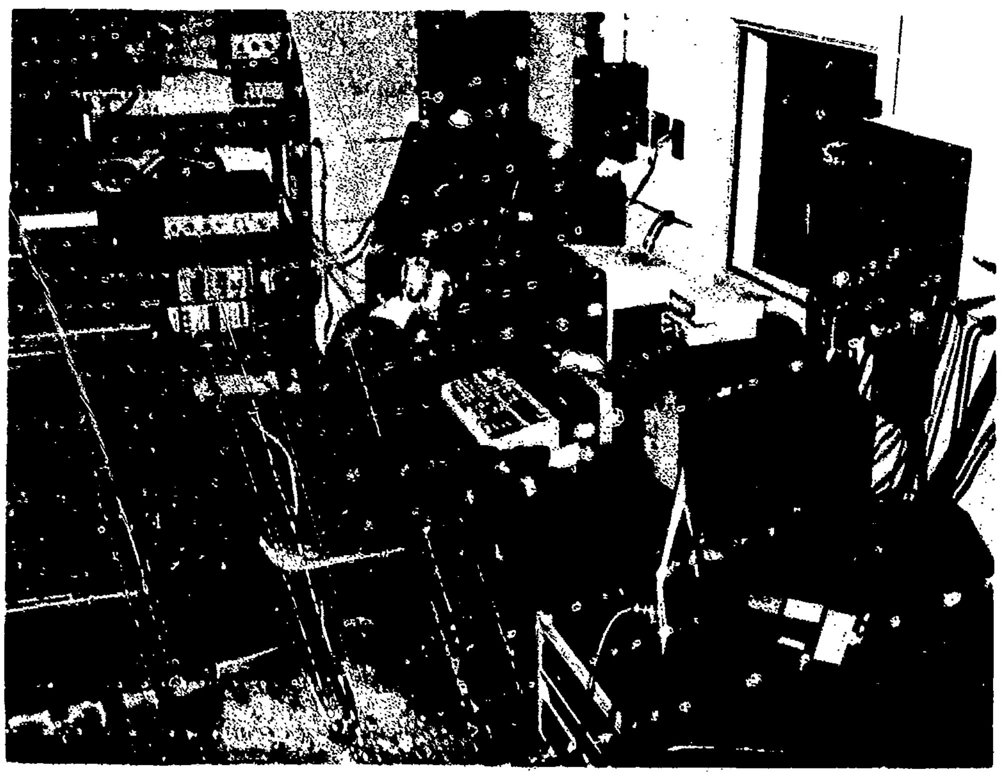

Figure 14. VOCRES SYSTEM

SUMMARY

This paper has described the VOCRES system, its capabilities and uses. In summary, VOCRES is a semiautomatic laboratory voice communication test system that uses human subjects in a realistic communication environment to conduct research, test and evaluation of Air Force communications systems and their effectiveness.

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